INSTRUMENTATION
INSTRUMENTATION
Teledyne Semiconductor
Instrumentation
1300 Terra Bella Ave.
Mountain View, California 94043

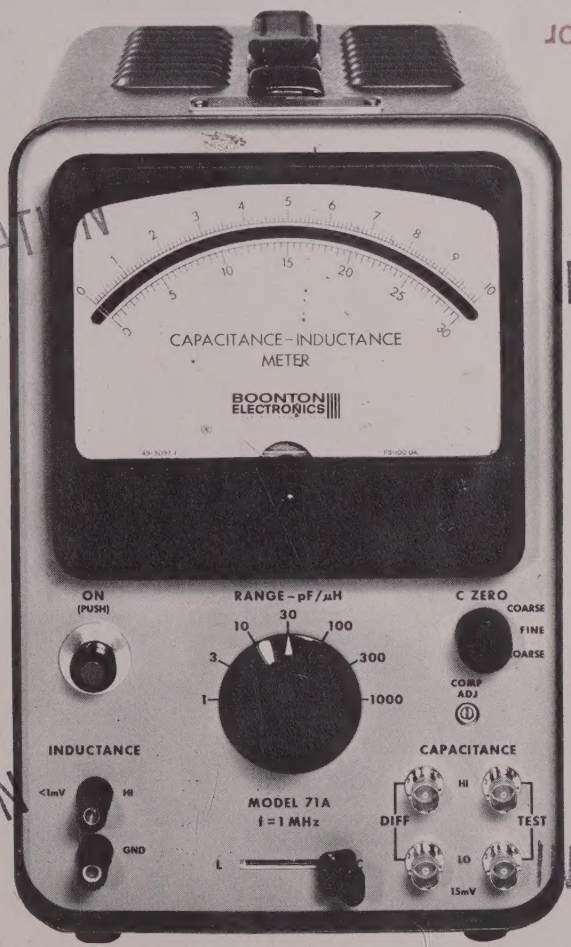
BOONTON ELECTRONICS CORPORATION

# OPERATING INSTRUCTIONS

## MODELS 71A & 71AR

## Capacitance/Inductance Meter

Teledyne Semiconductor
Instrumentation
1300 Terra Bella Ave.
Mountain View, California 94043




INSTRUMENTATION
INSTRUMENTATION
INSTRUMENTATION
INSTRUMENTATION
Teledyne Semiconductor
Instrumentation
1300 Terra Bella Ave.
Mountain View, California 94043
5/84/1077

BOONTON ELECTRONICS CORPORATION
TEL: 201-887-5110
TWX: 710-986-8241
ROUTE 287 AT SMITH ROAD
PARSIPPANY, N. J.— 07054

## ADDENDUM

For Model 71A and 71A-R's having serial numbers 400 and below.

The front panel control on these instruments, called "Cable Comp", is referred to in this book as "Comp Adj".

The terminals on these units called "STD" are referred to in this book as "DIFF".

It should be noted that these differences are in nomenclature only, and in all respects, electrical functions as described in this instruction book remain the same for all units.

## Table of Contents


| | | Page |
|---|---|---|
| Section I | Specifications | 1-1 |
| Section II | General Description | 2-1 |
| | 2.1 General Description, Model 71A | 2-1 |
| | 2.2 General Description, Model 71AR | 2-1 |
| | 2.3 Location of Controls and Adjustments, Model 71A | 2-2 |
| | 2.4 Location of Controls and Adjustments, Model 71AR | 2-3 |
| | 2.5 Explanation of Controls and Adjustments | 2-4 |
| Section III | Operating Instructions | 3-1 |
| | 3.1 Initital Installation | 3-1 |
| | 3.2 Capacitance Measurements | 3-3 |
| | 3.3 Local Capacitance Measurements | 3-3 |
| | 3.4 Remote Capacitance Measurements | 3-6 |
| | 3.5 Increasing Capacitance Measuring Range | 3-10 |
| | 3.6 Differential Capacitance Measurements | 3-10 |
| | 3.7 Extending the Range of the C ZERO Control | 3-11 |
| | 3.8 DC Bias for Capacitance Tests | 3-11 |
| | 3.9 Capacitance Test Signal | 3-12 |
| | 3.10 Capacitance Calibration Procedures | 3-12 |
| | 3.11 Inductance Measurements | 3-17 |
| | 3.12 Connection for Inductance Measurements | 3-17 |
| | 3.13 Inductance Zero Check | 3-17 |
| | 3.14 DC Output | 3-18 |
| | 3.15 "METER-OFF" Switch | 3-19 |
| List of Replaceable Parts | | Following Section III |
| Schematics | | Endfold |


## List of Figures


| | | |
|---|---|---|
| Figure 2-1 | Location of Controls and Adjustments, Model 71A | 2-2 |
| Figure 2-2 | Location of Controls and Adjustments, Model 71AR | 2-3 |
| Figure 3-1 | Correction for Series Inductance of Connecting Cables | 3-9 |

## Table of Contents (cont'd)


| | | Page |
|---|---|---|
| Figure 3-2 | Circuit for Applying High Voltage DC Bias to Capacitance Specimens | 3-13 |
| Figure 3-3 | Connection Errors for Inductance Measurements at 1 MHz | 3-20 |

## SECTION I

## Specifications

### Capacitance Measurements (Three-terminal)

Range: 0 to 1000 pF in 7 Ranges; lowest range, 1 pF, fs

Accuracy: 0.5% of reading + $(0.5\% + \frac{3}{Q}\%)$ fs + 0.01 pF

Resolution: 0.25%

### Inductance Measurements (Two-terminal)

Range: 0 to 1000 μH in 7 ranges; lowest range, 1 μH fs

Accuracy: 0.5% of reading + $(0.5\% + \frac{6}{Q}\% + \frac{L_{\mu H}^{*}}{500}\%)$ fs + 0.01 μH

( * Where $L_{\mu H}$ = Inductance of the test specimen)

Resolution: 0.25%

### Test Signal

Frequency: 1 MHz, crystal controlled

Level: Capacitance measurements, 15 mV;
Inductance measurements, less than 1 mV

### DC Bias (For Capacitance Measurements Only)

External bias up to ±200 V @ 250 mA may be applied at rear terminals; bias circuit protected from overload by 250 mA fuse

### DC Analog Output

Level: 0 to 100 mV or 0 to 300 mV depending on full scale numerics; also $>$1 V fs for loads $>$10 MΩ

Linearity: 0.1% of reading + 0.005% fs

Response Time: 10 milliseconds (approx)

### Primary Power

117 or 234 V (±10%), 50/60 cps: 40 watts

### Physical Dimensions

Model 71A: 7 1/4" w x 10 1/4" d x 11" h; weight 12 lbs; packed for shipment, 16 lbs.

Model 71AR: 7" x 19" (panel size); depth in rack, 9"; weight, 14 lbs; packed for shipment, 21 lbs.

## SECTION II

## General Description

### 2.1 Model 71A

The Model 71A provides instant, direct-reading, three-terminal capacitance measurements and two-terminal inductance measurements at 1 MHz. The measuring capabilities of 0 to 1000 pF and 0 to 1000 μH are each covered in 7 ranges in a 1-3-10 sequence.

The internally supplied 1 MHz test signal is crystal controlled. The instrument operates with low test levels as required for many semiconductor measurements.

Terminals at a rear panel permit application on an externally supplied dc bias up to ±200 volts to the test specimen on capacitance measurements only. Bias cannot be provided for inductance measurements.

A linear dc output is available at rear panel terminals which is proportional to the meter reading. This output extends the range of application beyond laboratory measurements to include production testing as well as a variety of control functions.

### 2.2 Model 71AR

The Model 71AR provides the performance characteristics of the Model 71A in rack-mounting form. In every respect its electrical specifications are identical to those of the bench unit. In addition, the Model 71-1A Standard Capacitor is incorporated in the Model 71AR and is switched into service by a front panel selector.

* * *

For the location and explanation of all controls and adjustments of the Models 71A and 71AR, see pages 2-2 through 2-7.

## 2.3 Location of Controls and Adjustments, Model 71A

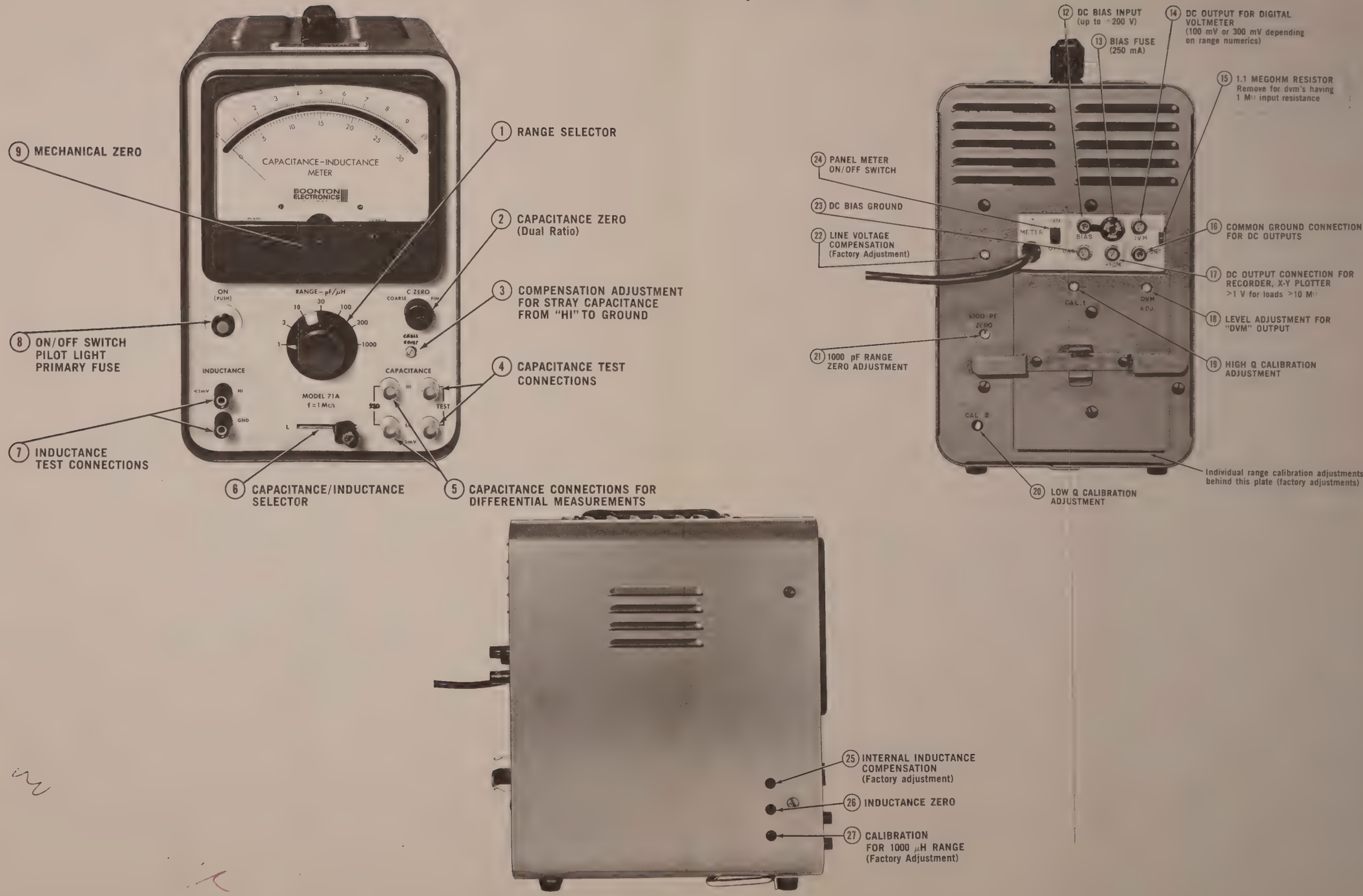
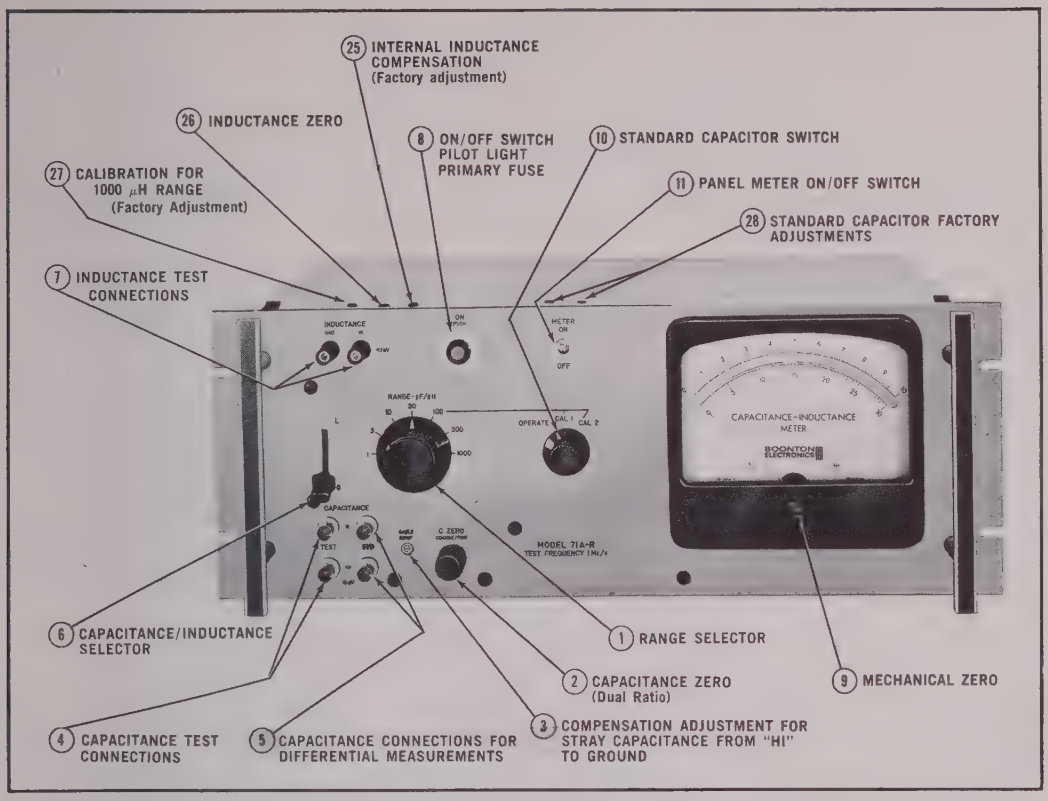

CAPACITANCE-INDUCTANCE METER
BOONTON ELECTRONICS
MODEL 71A
f = 1 Mc/s
ON (PUSH)
RANGE – pF/μH
C ZERO
COARSE
FINE
INDUCTANCE
CAPACITANCE
TEST
9 MECHANICAL ZERO
1 RANGE SELECTOR
2 CAPACITANCE ZERO (Dual Ratio)
3 COMPENSATION ADJUSTMENT FOR STRAY CAPACITANCE FROM "HI" TO GROUND
4 CAPACITANCE TEST CONNECTIONS
8 ON/OFF SWITCH PILOT LIGHT PRIMARY FUSE
7 INDUCTANCE TEST CONNECTIONS
6 CAPACITANCE/INDUCTANCE SELECTOR
5 CAPACITANCE CONNECTIONS FOR DIFFERENTIAL MEASUREMENTS
12 DC BIAS INPUT (up to ±200 V)
13 BIAS FUSE (250 mA)
14 DC OUTPUT FOR DIGITAL VOLTMETER (100 mV or 300 mV depending on range numerics)
15 1.1 MEGOHM RESISTOR Remove for dvm's having 1 MΩ input resistance
24 PANEL METER ON/OFF SWITCH
23 DC BIAS GROUND
22 LINE VOLTAGE COMPENSATION (Factory Adjustment)
16 COMMON GROUND CONNECTION FOR DC OUTPUTS
17 DC OUTPUT CONNECTION FOR RECORDER, X-Y PLOTTER >1 V for loads >10 MΩ
18 LEVEL ADJUSTMENT FOR "DVM" OUTPUT
19 HIGH Q CALIBRATION ADJUSTMENT
21 1000 pF RANGE ZERO ADJUSTMENT
20 LOW Q CALIBRATION ADJUSTMENT
Individual range calibration adjustments behind this plate (factory adjustments)
25 INTERNAL INDUCTANCE COMPENSATION (Factory adjustment)
26 INDUCTANCE ZERO
27 CALIBRATION FOR 1000 μH RANGE (Factory Adjustment)

Figure 2-1

## 2.4 Location of Controls and Adjustments, Model 71AR


25 INTERNAL INDUCTANCE COMPENSATION (Factory adjustment)
26 INDUCTANCE ZERO
8 ON/OFF SWITCH PILOT LIGHT PRIMARY FUSE
10 STANDARD CAPACITOR SWITCH
27 CALIBRATION FOR 1000 μH RANGE (Factory Adjustment)
11 PANEL METER ON/OFF SWITCH
28 STANDARD CAPACITOR FACTORY ADJUSTMENTS
7 INDUCTANCE TEST CONNECTIONS
CAPACITANCE-INDUCTANCE METER
MODEL 71A-R
6 CAPACITANCE/INDUCTANCE SELECTOR
1 RANGE SELECTOR
2 CAPACITANCE ZERO (Dual Ratio)
9 MECHANICAL ZERO
4 CAPACITANCE TEST CONNECTIONS
5 CAPACITANCE CONNECTIONS FOR DIFFERENTIAL MEASUREMENTS
3 COMPENSATION ADJUSTMENT FOR STRAY CAPACITANCE FROM "HI" TO GROUND

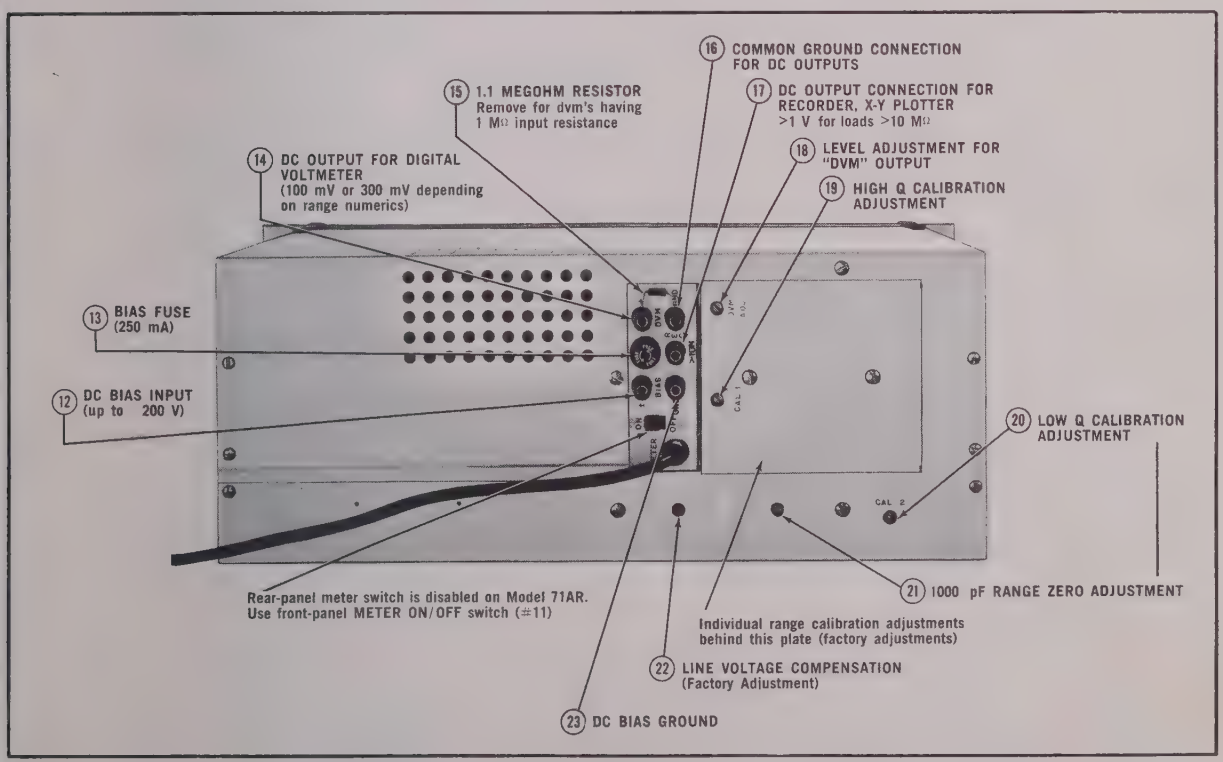

16 COMMON GROUND CONNECTION FOR DC OUTPUTS
15 1.1 MEGOHM RESISTOR Remove for dvm's having 1 MΩ input resistance
17 DC OUTPUT CONNECTION FOR RECORDER, X-Y PLOTTER >1 V for loads >10 MΩ
18 LEVEL ADJUSTMENT FOR "DVM" OUTPUT
14 DC OUTPUT FOR DIGITAL VOLTMETER (100 mV or 300 mV depending on range numerics)
19 HIGH Q CALIBRATION ADJUSTMENT
13 BIAS FUSE (250 mA)
12 DC BIAS INPUT (up to 200 V)
20 LOW Q CALIBRATION ADJUSTMENT
Rear-panel meter switch is disabled on Model 71AR. Use front-panel METER ON/OFF switch (#11)
21 1000 pF RANGE ZERO ADJUSTMENT
Individual range calibration adjustments behind this plate (factory adjustments)
22 LINE VOLTAGE COMPENSATION (Factory Adjustment)
23 DC BIAS GROUND

Figure 2-2

## 2.5 Explanation of Controls and Adjustments

### 2.5.1 Front Panel, Models 71A and 71AR

(1) RANGE - pF/μH: Seven-position switch selects measuring ranges having full scale values of 1, 3, 10, 30, 100, 300, or 1000, with units of measurement being either picofarads or microhenries, as determined by the position of the "L/C" selector.

(2) C ZERO: Provides means for balancing out capacitance across the "TEST" terminals (up to approximately 7 pF) contributed by exposed terminations of connecting cables, test fixtures, etc. Its range may be increased by attaching an external capacitance to the "DIFF" posts, as outlined in paragraph 3.7.

NOTE

This is a dual ratio control which adjusts a variable air capacitor having a full 360° of rotation. It will be noted that for about 270° of rotation of the "C ZERO" control, it turns very easily. Beyond this point the torque requirement increases abruptly, indicating a shift from the 36:1 "fine" ratio to the 6:1 "coarse" ratio.

(3) COMP ADJ: The front panel "COMP ADJ" control adjusts a variable air capacitor which negates stray capacitance from the high post to ground (such as those existing between the inner and outer conductors of coaxial cable) to eliminate its effects on measurements. This control will tune out approximately 100 pF. As a rule of thumb, the amount of "HI"-post-to-ground capacitance required to cause 1% of full-scale error is somewhat greater than two times the full scale value of the range for all ranges. Thus, it can be seen that the amount of "HI"-post-to-ground capacitance encountered in the great majority of cases will be of minor significance, and require balancing only on the lower ranges. However, when working on the 30 pF range or lower, the "COMP ADJ" adjustment should be checked when:

(a) The instrument is initially put into service.

(b) Any change is made in the connection system. (For example, going from remote measurements to local measurements or vice versa, changing connecting cables or test fixtures, etc.).

(c) Measuring a standard capacitor.

(d) Testing a specimen having markedly different "HI"-to-ground capacitance than those tested previously with a given connection system (as caused by considerable differences in internal construction, encasing, or terminations).

(4) CAPACITANCE TEST: BNC connectors for the test specimen. Measurements may be made either locally or remotely by means of coaxial cables.

(5) CAPACITANCE DIFF: A given capacitance connected to the "TEST" terminals produces an accurately calibrated up-scale reading. Attaching the same capacitance to the "DIFF" post causes a comparable down-scale reading. These connections are useful for such functions as making differential capacitance measurements, extending the measuring range upwards, or extending the range of the "C ZERO" control. There are certain limitations on the use of the "DIFF" posts which are detailed in paragraphs 3.5, 3.6, and 3.7.

(6) L/C: This switch selects a condition for measurement of either inductance or capacitance.

(7) INDUCTANCE: Test terminals for inductance measurements. Measurements should be made directly at the terminals. Use of even short test leads should be avoided, if possible.

(8) ON (PUSH): The main power switch (push for on, pull for off); the translucent red button serves as the pilot light. This assembly also contains the primary power fuse, which may be removed by rotating the black ring counterclockwise and withdrawing the fuse holder.

(9) MECHANICAL ZERO: This adjusts the meter pointer to a mechanical zero. It should be checked with the instrument switched off.

(10) OPERATE/CAL 1/CAL 2 (Model 71AR only): For measuring, this selector is left in the "OPERATE" position. Set the "CAL 1" and "CAL 2", it switches in the internal 100 pF standard capacitor for high-Q and low-Q calibration checks, respectively. (See paragraph 3.10.4.)

(11) METER ON/OFF (Model 71AR only): There is no interaction between the indicating meter and the dc output except for a small counter-emf from the moving coil of the meter move-

ment. With varying meter readings, this emf may show up as slight irregularities in the dc output; switching the meter off eliminates this. In addition, switching the meter off eliminates needless wear of the meter movement when the dc output is used for widely varying test values. (In the Model 71A, this function is performed by the rear panel "METER ON/OFF" switch, control #22.) This control is inoperative on the 71A-R.

2.5.2 Rear Panel, Models 71A and 71AR

(12) ± BIAS: This terminal and BIAS GND (#23) provide for application of the dc bias voltage up to ±200 volts at 250 mA to the capacitance test specimen. Bias voltage appears across both "TEST" and "DIFF" terminals.

(13) FUSE: 250 mA fuse prevents internal damage in case the bias voltage is short-circuited at the "TEST" or "DIFF" terminals either by accidental contact or by a shorted test specimen. See paragraph 3.8 for further details.

(14) DVM+: Connection to this terminal and the "GND" terminal (#16) immediately below provides a dc analog of the measured value suitable for use with a digital voltmeter. Output for full-scale is 100 mV or 300 mV depending upon numerics of the selected range, so that when ranges are switched the dvm follows automatically.

(15) 1.1 MΩ RESISTOR: For dvm's having an input resistance of 10 megohms or greater, this resistor should be left in position. For dvm's having an input resistance of 1 megohm, it should be removed.

(16) GND: Ground connection for DVM or REC output.

(17) REC: Connection to this terminal and to the "GND" terminal (#16) provides a linear analog output of the measured value, whose level varies from 0 to approximately 1.7 volts (into loads greater than 10 megohms) for full-scale on all ranges.

(18) DVM ADJ: This control adjusts the level of the dc analog output so that the dvm will be in agreement with a standard capacitor. See paragraph 3.14.4.

(19) CAL 1: Calibration adjustment for high Q measurements. For calibration procedures, see paragraph 3.10.

(20) CAL 2: Calibration adjustment for low Q measurements. For calibration procedures, see paragraph 3.10.

(21) 1000 pF ZERO: Zero adjustment for 1000 pF range. Once set on initial installation, this control will rarely need readjustment. However, since the setting of this control is vital to proper operation for either capacitance or inductance measurements, it is recommended that it be checked periodically. (See paragraph 3.1.4, (f) & (g) for procedure.)

(22) Line Voltage Compensation: Factory adjustment to assure insensitivity to line voltage changes from 105 to 125 V, ac.

(23) GND: Ground connection for dc bias input.

(24) METER ON/OFF, Model 71A only): There is no interaction between the indicating meter and the dc output except for a small counter-emf from the moving coil of the meter movement. With varying meter readings, this emf may show up as slight irregularities in the dc output; switching the meter off eliminates this. NOTE: In the Model 71AR this function is performed by front panel switch #11. While this switch is present at the rear of the Model 71AR, it is disabled.

2.5.3 Model 71A, Left side; Model 71AR, Top

(25) INTERNAL INDUCTANCE COMPENSATION: This factory adjustment compensates for inductance of internal wiring. Pre-set at the factory, this control does not require readjustment.

(26) L ZERO: This control provides a means for zeroing the instrument on the 1 μH range in accordance with the procedure outlined in paragraph 3.13.

(27) 1000 μH CALIBRATION: This control provides means for individually calibrating the 1000 μH range; it is pre-set at the factory and does not require readjustment.

(28) Adjustments for the internal 100 pF standard capacitor. These are set at the factory and do not require readjustment.

SECTION III

Operating Instructions

## 3.1 Initial Installation

### 3.1.1 Unpacking

On unpacking, inspect the instrument for possible damage in transit. If the instrument is damaged, contact your local Sales Engineering Representative or the factory (see title page for factory address) for further instructions. If no damage is found, the instrument may be put into service by the following procedure:

### 3.1.2 Mechanical Zero Adjustment

With the instrument unpowered and in a normal operating position, check to see that the indicator needle rests at zero. If not, set to zero by adjusting the mechanical zero control on the meter housing.

### 3.1.3 Turn-on Procedure and Warm-up

Plug the instrument into a source of 117 V (±10%) 50/60 Hz power and push the front panel ON button. (Note: The translucent red center button of the ON switch also serves as the pilot light. This switch is turned off by pulling the outer black disk outward. It should be noted that this switch also serves as the fuse holder. (To remove the fuse, turn the switch off, twist the black ring counterclockwise, and withdraw the assembly.) The instrument may be operated approximately 30 seconds after turn-on. However, for maximum accuracy, a warm-up of approximately a half-hour should be allowed.

### 3.1.4 Initial Installation Checks and Adjustments

#### 3.1.4.1 General

Before the instrument is put into service, there are several initial checks which should be made, and, if necessary, adjustments performed:

3.1.4.2 (a) Allow an initial warm-up of a half hour.

(b) Set the L/C selector to C.

## 3.2 Capacitance Measurements

With the front panel "L-C" selector in the "C" position, the Models 71A and 71AR measure the "direct" capacitance of the test specimen. (The instruments ignore stray capacitance from the "LO" post to ground. Up to about 100 pF of capacitance from the "HI" post to ground can be nulled by adjustment of the "COMP ADJ" control. As a result, the Models 71A and 71AR measure only the capacitance appearing between the "HI" and "LO" terminals.)

The measurements may be made either at the "TEST" terminals or remotely by connecting the specimen or test fixture via coaxial cables to the "TEST" terminals. By use of both the "DIFF" and "TEST" terminals differential capacitance measurements may be made within certain limitations.

## 3.3 Local Capacitance Measurements

### 3.3.1 Connections for Local Measurements

While the capacitance connectors of the Models 71A and 71AR are intended primarily for attachment of coaxial cables, tests may readily be made locally by connecting the specimen directly to the terminals. A pair of Type UG-1090/U or comparable BNC-to-binding-post adapters are particularly convenient for this purpose, although for quick measurements the leads of the component may be simply inserted in the center receptables of the BNC terminals.

NOTE

If any length of coaxial cables is used for connection, even if they are only a few inches in length, the measurement is considered not local, but is remote and the instructions of paragraph 3.4 apply.

### 3.3.2 Checks and Adjustment Prior to Making Local Measurements

There are three controls whose adjustment should be checked before measuring at the terminals of the Model 71A or 71AR:

(a) "1000 pF ZERO"

(b) "COMP ADJ"

(c) "C ZERO"

(c) With the instrument on the 1 pF range, and no specimen connected to the "TEST" terminals, set the indicator to about 75% of full scale using the front panel "C ZERO" control.

(d) Adjust the front panel "COMP ADJ" control for a peak reading. (Readjust the "C ZERO" control to keep indications on-scale if necessary).

(e) Having achieved a peak reading, return the indicator to zero using the "C ZERO" control.

(f) Switch to the 1000 pF range, and observe the zero position of the indicator. If required, set to zero using the "1000 pF ZERO" at the rear panel.

(g) Switch one range at a time back to the 1 pF range, observing the zero position of the indicator for each range. If the zero position shifts appreciably for any range, repeat steps (c) through (g). When properly adjusted, the zero position should be constant for all ranges.

NOTE

Once properly set, the "1000 pF ZERO" rarely needs readjustment. However, since its setting is essential to the proper operation of the instrument for either capacitance or inductance measurement, it is advisable to check it, following steps (f) and (g) above, at fairly frequent intervals.

(h) Stretch a short length of #22 copper wire between the "INDUCTANCE" terminals.

(j) Switch the "L/C" switch to the "L" position. The indicator should rest one minor division up-scale from zero. If not, adjust for this reading using the "L ZERO" control (the center adjustment on the left side of the instrument).

### 3.3.2.1 "1000 pF ZERO" Adjustment

The "1000 pF ZERO" control is located at the rear panel. Its setting is checked by switching to the 1000 pF range and, with no specimen attached at the "TEST" terminals, observing the rest position of the pointer. If it does not read zero, follow the adjustment procedure outlined in paragraph 3.1.4, (f) and (g).

### 3.3.2.2 "COMP ADJ" Peaking Adjustment

Prior to measuring at the "TEST" terminals, the "COMP ADJ" peaking adjustment should be performed as follows:

(a) Attach any terminal adapters or connectors to be used for subsequent measurements to the "TEST" terminals and set the "RANGE" selector to the 1 pF range.

(b) Adjust the "C ZERO" control for a reading of approximately 75% of full scale.

(c) Adjust the "COMP ADJ" control for a maximum reading. (Readjust the "C ZERO" control to keep deflections on scale if required.)

(d) After peaking, zero the pointer using the "C ZERO" control.

Once adjusted, the "COMP ADJ" control need not be re-adjusted (although periodic checking during extended periods of operation is advisable) unless some change in either the method of connection or the nature of the test samples substantially affects the stray capacitance from the "HI" post to ground. In such cases, readjustment of the "COMP ADJ" control is required.

The above "COMP ADJ" adjustment procedure will suffice for the majority of measurements at the terminals for all ranges. However, to obtain the greatest possible accuracy when measuring high Q (>10) components on the 1, 3, 10 or 30 pF range, and when the test sample has significant capacitance from the "HI" post to ground, the following procedure should be follows:

(a) Attach whatever terminal adapters or connectors are to be used in subsequent measurements to the "TEST" posts and connect a specimen typical of

those to be measured. If no connectors are to be used, insert the leads of the specimen in the center conductors of the "TEST" posts.

(b) Set the "RANGE" selector to the lowest range on which a reading of approximately 75% of full scale is possible. (On the lower ranges the "C ZERO" control may be of help in obtaining this reading.)

(c) Adjust the "COMP ADJ" for peak reading. (Readjust the "C ZERO" to keep deflections on scale if necessary.)

(d) Disconnect the specimen from the low post, leaving any terminal adapters to be used for subsequent tests in position; zero the pointer with the "C ZERO" control.

3.3.2.3 "C ZERO" Adjustment

The front panel "C ZERO" adjustment is checked by switching to the 1 pF range. With the "COMP ADJ" control properly peaked and no specimen across the test terminals, observe the rest position of the pointer. If necessary, the pointer should be brought to zero using the front panel control. Any terminal adapters to be used in subsequent measurements should be left installed for this adjustment.

With "100 pF ZERO" and "C ZERO" controls properly set, the instrument will be correctly zeroed for all ranges, assuming the "COMP ADJ" control is properly adjusted.

It is advisable to check the 1 pF zero position periodically during the course of operation, particularly if working on the 1 or 3 pF ranges.

NOTE

The front panel "C ZERO" control is a dual ratio control which adjusts a variable air capacitor having a full 360° of rotation. It will be noted that the "C ZERO" control turns very easily for about 270° of rotation. At this point the torque requirement increases abruptly, indicating a shift from the 36:1 "fine" adjustment to the 6:1 "coarse" adjustment.

## 3.4 Remote Capacitance Measurements

### 3.4.1 Connections for Remote Measurements

A test specimen or a test fixture may be connected to the "TEST" terminals by coaxial cables. RG-62/U is particularly recommended for this purpose because of its low capacitance.

To minimize errors in measurement resulting from the series inductance of the coaxial cable, the length of each of the two cables should be less than approximately 5 feet on the 1, 3, and 10 pF ranges, with shorter lengths on higher ranges. Figure 3-1, which indicates correction factors for cable inductance, may be used as a guide in selecting practical cable lengths.

### 3.4.2 Initial Adjustment for Remote Measurements

There are three controls whose adjustment should be checked before making remote measurements with this instrument:

(a) "1000 pF ZERO"

(b) "COMP ADJ"

(c) "C ZERO"

#### 3.4.2.1 "1000 pF ZERO" Adjustment

The "1000 pF ZERO" control is located at the rear panel. Its setting is checked by switching to the 1000 pF range and, with no specimen attached at the "TEST" terminals, observing the rest position of the pointer. If it does not read zero, follow the adjustment procedure outlined in paragraph 3.1.4, (f) and (g).

#### 3.4.2.2 "COMP ADJ" Peaking Adjustment

Prior to measuring remotely, the "COMP ADJ" peaking adjustment must be performed as follows:

(a) Connect the coaxial cables and test fixture (if any) to be used in subsequent measurements to the "TEST" terminals. Set the range selector to the 1 pF range.

(b) Adjust the "C ZERO" control for a reading of approximately 75% of full scale.

(c) Adjust the "COMP ADJ" control for a maximum reading. (Readjust the "C ZERO" control to keep deflections on scale if required).

(d) After peaking, zero the pointer using the "C ZERO" control.

Once adjusted, the "COMP ADJ" control need not be readjusted for some time (although periodic checking during extended periods of operation is advisable) unless some change in either the connection system or the nature of the test samples substantially effects the stray capacitance from the "HI" post to ground. In such cases, readjustment of the "COMP ADJ" control is required.

The above "COMP ADJ" adjustment procedure will suffice for the majority of remote measurements. However, to obtain the greatest possible accuracy when using the 1, 3, 10 or 30 pF range, and when the specimen has significant capacitance from the "HI" post to ground, the following procedure should be followed:

(a) Attach the coaxial cables and test fixture (if any) which are to be used in subsequent measure ments to the "TEST" posts and connect a specimen typical of those to be measured.

(b) Set the "RANGE" selector to the lowest range on which, using the "C ZERO" control, a reading of approximately 75% of full scale is possible.

(c) Adjust the "COMP ADJ" for peak reading. (Readjust the "C ZERO" to keep deflections on scale if necessary.)

(d) Disconnect the cable at the low post and zero the pointer with the "C ZERO" control (see paragraph 3.4.2.3 below).

3.4.2.3 "C ZERO" Adjustment

The front panel "C ZERO" adjustment is checked by switching to the 1 pF range. With the "COMP ADJ" control properly peaked and no specimen across the test terminals, observe the rest position of the pointer. If necessary, the pointer should be brought to zero using the front panel "C ZERO" control. (The coaxial cables and test

fixture to be used in subsequent measurements should be attached for this adjustment.)

With the "1000 pF ZERO" and "C ZERO" controls properly set, the instrument will be correctly zeroed for all ranges, assuming the "COMP ADJ" control is properly adjusted.

It is advisable to check the 1 pF zero position periodically during the course of operation, particularly if working on the 1 or 3 pF ranges.

NOTE

The front panel "C ZERO" control is a dual ratio control which adjusts a variable air capacitor having a full 360° of rotation. It will be noted that the "C ZERO" control turns very easily for about 270° of rotation. At this point the torque requirement increases abruptly, indicating a shift from the 36:1 "fine" adjustment to the 6:1 "coarse" adjustment. If it is found that the "C ZERO" range is inadequate to zero out the external capacitance, its range may be extended as outlined in paragraph 3.7.

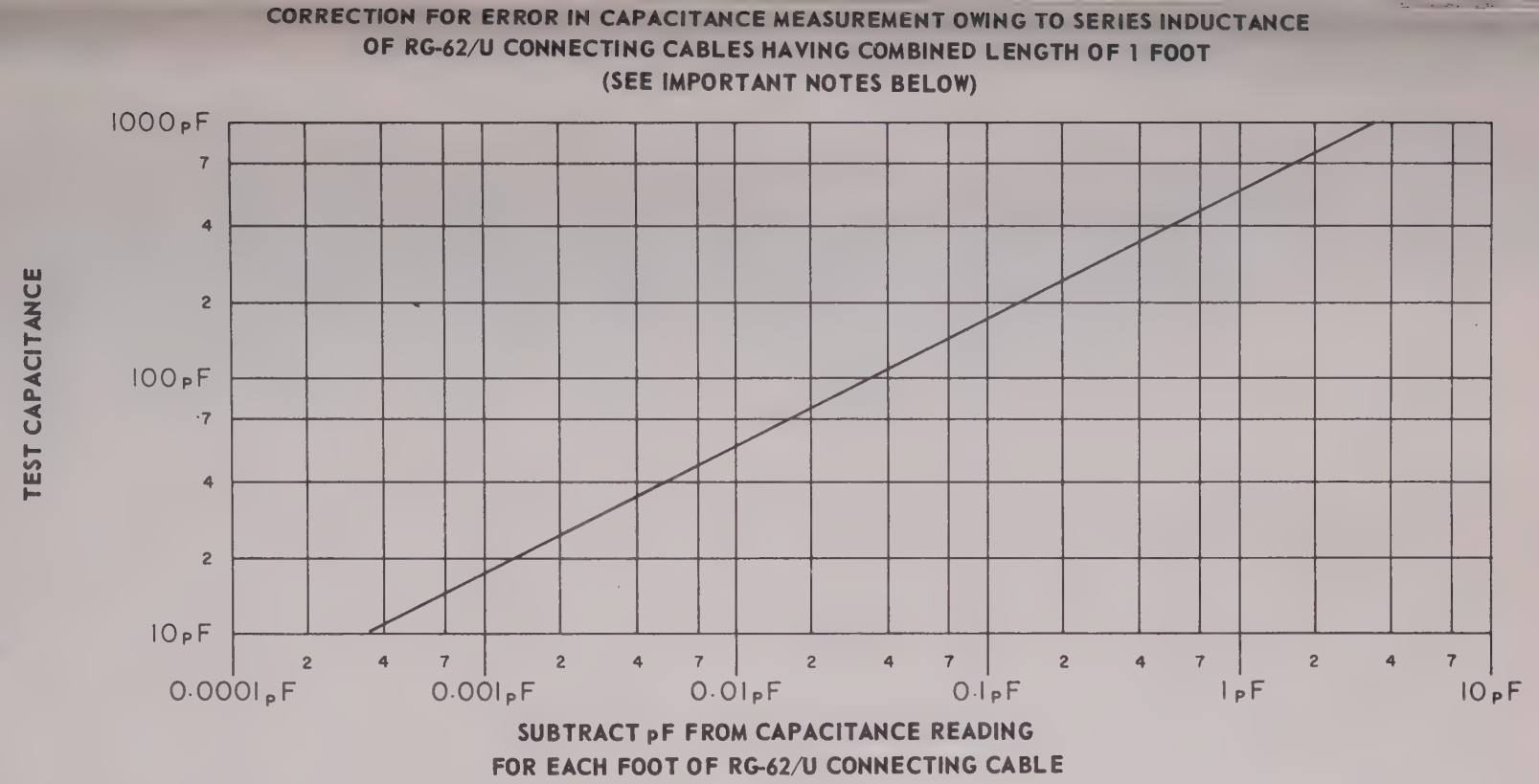
### 3.4.3 Errors in Capacitance Measurements Resulting from Series Inductance of Connecting Cables.

The measured capacitance, $C_m$, of a specimen may differ from the true capacitance, $C_t$, as a result of the series inductance of connecting cables, and the inductance of the specimen. The error will be noted as an apparent increase in capacitance value in accordance with the following expression:

$$C_m = \frac{C_t}{1-\omega^2 L C_t} = \frac{C_t}{1-(X_L/XC_t)}$$

Where L = the combined series inductance in microhenries of BOTH lengths of connecting coaxial cable and the inductance of the sample (generally small with respect to the cable inductance).

The correction chart of Figure 3-1 indicates typical corrections to be subtracted from the measured value for a pair of 1-foot cables of RG-62/U at 1 MHz for test values




NOTES

1. Since the effect of series inductance is to cause an apparent increase in capacitance, the correction is subtracted from the measured value.

2. Correction values shown in this table are for a pair of RG-62/U cables having a combined length of 1 foot. (correction for RG-58/U are not substantially different.) The two cables need not be of the same length.

3. Since the correction is very nearly a direct function of cable length for small corrections (10% or less), the correction for cable pairs of other lengths may be computed from the ratio to 1 foot.

4. It is essential that BOTH ends of the cable shields be well grounded.

Figure 3-1

from approximately 10 pF to 1000 pF. Because this correction factor is very nearly a direct function of cable length, for small corrections (10% or less), the correction required for pairs of other lengths can be readily computed.

## 3.5 Increasing the Capacitance Measuring Range

The upper capacitance limt of 1000 pF may be increased by a factor of up to approximately 10 (to 0.01μF) by use of the "DIFF" posts, as follows:

(a) Set the instrument to the 1000 pF range.

(b) Attach a high quality mica capacitor whose value is accurately known to the "DIFF" terminals.

(c) Attach the specimen to the "TEST" terminals.

(d) The sum of the meter reading and the value of the capacitor at the "DIFF" terminals is the value of the test.

NOTE

The value of the capacitor at the "DIFF" terminals should be selected to provide at least 15% of full scale deflection for most satisfactory results. It should be noted that while significant measurements can be made in this manner, accuracy will be degraded somewhat from that specified for the normal operating range of the instrument.

## 3.6 Differential Capacitance Measurements

Measurement of the capacitance differential between two specimens may be made by attaching one sample at the "DIFF" terminals and the other to the "TEST" terminals, using all but the 1 pF range. The scale will read the capacitance differential directly in pF. (NOTE: If a down-scale reading is obtained, interchange the specimens connected to the "TEST" and "DIFF" posts for an up-scale reading.) The measurements must be made using the range on which one of the specimens alone would normally be measured, or one range below this for increased resolution. However, it is important not to switch down more than 1 range or serious errors may be introduced. Remote differential measurements may also be made using coaxial cables

for connection. Samples connected for differential measurement may both be biased, since any voltage applied to the dc bias input appears across both the "TEST" and "DIFF" terminals.

Remote differential measurements may be made by connecting the specimens to the "TEST" and "DIFF" terminals with coaxial cables. The "COMP ADJ" adjustment procedures for remote differential measurements are the same as those for absolute measurements (see paragraph 3.4.2) except that the required connections and disconnections are made simultaneously at both sets of terminals.

## 3.7 Extending the Range of the "C ZERO" Control

The front panel "C ZERO" control has sufficient range to zero out capacitance up to approximately 7 pF between the "HI" and "LO" test terminals. If it is found that greater range is required to zero out the capacitance of an external fixture, the range may be extended up to approximately 30 pF by connecting a high quality mica capacitor between the "HI" and "LO" "DIFF" posts. The amount of "C ZERO" range extension will equal the value of the capacitor at the "DIFF" terminals.

## 3.8 DC Bias for Capacitance Tests

### 3.8.1 Application at the "BIAS" Terminals

The capacitance specimen may be biased by applying a dc voltage up to ±200 volts at 250 mA to the dc bias binding posts at the rear of the instrument. Since any voltage applied to these binding posts appears across both the "TEST" and "DIFF" terminals, specimens for differential measurement are subjected to identical bias conditions.

NOTE

In instruments having serial number 140 or above, a fuse has been inserted in the dc bias circuit. This prevents internal damage in case the bias voltage is short-circuited at the "TEST" or "DIFF" terminals either by accidental contact or by a shorted test specimen. If no bias appears at the "TEST" and "DIFF" terminals, regardless of the indication of the monitor of the bias supply, the condition of this fuse (located at the rear panel) should be checked. If frequent blowing of this fuse is experienced, an external current limiting resistor of approximately 100 K ohms may be connected in series with the bias terminal.

Instruments having serial numbers between 140 and 191 (inclusive), a 100 K ohm resistor is installed across the fuse holder. Thus, if the fuse blows, bias voltage will still appear at the "TEST" terminals but usually at a somewhat lower level than is indicated by the bias supply monitor. If such a voltage differential is observed in these instruments, the condition of the fuse should be checked. The resistor, which was intended for current limiting with the fuse removed, may be deleted from the circuit if desired. (NOTE: This resistor is not installed in instruments having serial numbers 192 and above.)

### 3.8.2 Connection for High Voltage DC Bias

In cases where a dc bias voltage of greater than 200 volts is required, the circuit shown in Figure 3-2 may be used. With this arrangement, the practical limit of the bias that can be applied is the working voltage of the capacitor, C.

## 3.9 Capacitance Test Signal

For capacitance measurements, the crystal controlled 1 MHz test signal is fixed at 15 millivolts RMS (±1mV). It is not adjustable, and any attempts to alter the test level will have a severe effect on measuring accuracy.

## 3.10 Capacitance Calibration Procedures

### 3.10.1 General

Calibration of the Models 71A and 71AR* should be checked and adjusted using both high Q and low Q (Q=3) tests. It is not advisable to check and adjust calibration at either the upper or lower limit of the measuring range; hence a standard of 100 pF is particularly recommended. In any case, the capacitance standard used must be a three-terminal device capable of operation at 1 MHz.

The Boonton Electronics Model 71-1A Capacitance Standard is designed specifically for use with the Model 71A and is available as a separate accessory. It is a three-terminal 1 MHz standard which is adjusted to 100 pF (±.25%) against

NOTE: * The Model 71-1A Standard Capacitor is built into the Model 71AR. See paragraph 3.10.4.

# CONNECTIONS FOR EXTERNAL BIAS - 71A, 71AR, & 71CR

$C_2 \approx 200(C_{TEST})$, WITH VOLTAGE RATING > E

$L_1$ & $C_1$ TO RESONATE @ 1MHz. $Q_\omega L_1 > 200K$ ($L_1 \approx 150\mu H$; $Q > 200$)

$RC \leq 0.002$ SECONDS.

NOTE: L103 MAY BE USED FOR L1. L103 MAY BE ORDERED FROM BOONTON ELECTRONICS CORP., PART NO. 400124; PRICE $7.50 EACH; MINIMUM ORDER $15.00.

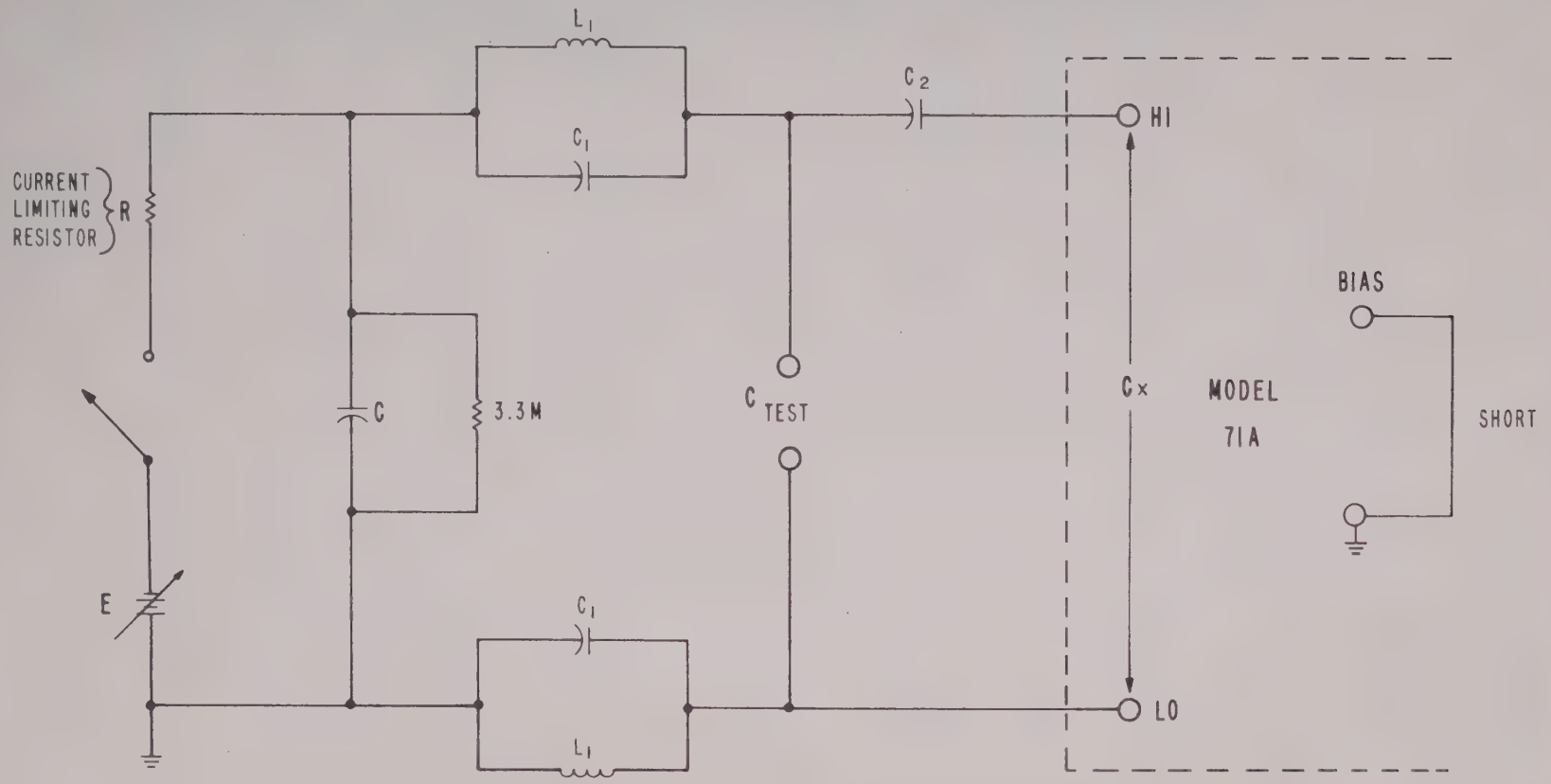



Figure 3-2

Dwg 830374B

references traceable to the National Bureau of Standards. It provides a particularly convenient means for checking the calibration of the Model 71A for both high Q and low Q (Q=3) measurements.

### 3.10.2 Calibration Check of the Model 71A with the Model 71-1A Standard Capacitor

(a) Remove all cables and adapters from the "TEST" and "STD" terminals.

(b) Set the instrument to the 1 pF range and adjust the "COMP ADJ" control as explained in paragraph 3.3.2.2.

(c) After zeroing the instrument on the 1 pF range, switch to the 100 pF range.

(d) Plug the Model 71-1A into the test terminals of the Model 71A and observe the reading.

(e) Depress the switch on the case of the Model 71-1A and again observe the reading.

If a reading of 100 pF is obtained for both readings the instrument is in calibration. Otherwise, perform the following calibration adjustments:

(a) With the Model 71-1A connected at the "TEST" terminals and without depressing the switch, set the rear-panel "CAL 1" adjustment for a reading of 100 pF.

(b) Depress the red button on the standard capacitor, reducing its Q to 3, and adjust the rear-panel "CAL 2" control so that the meter again reads 100 pF.

(c) Release the switch. If the instrument still reads 100 pF, calibration is complete. If not, repeat Steps a, b, and c until the instrument reads 100 pF for both tests.

### 3.10.3 Calibration Check of Model 71A with a Standard Other Than the Model 71-1A

The use of a conventional three-terminal capacitance standard for low Q calibration is not recommended owing to the uncertainty of the capacitance of the resistor which must be

added for the low Q check. However, if it is necessary to use this method, it is suggested that the capacitance standard be in the order of 100 pF and that the capacitance of the resistor be assumed to be 0.5 pF. This also has the advantage of requiring a resistor of sufficiently low value (approximately 5000 ohms) so that the effective 1 Mc resistance will be very nearly the dc value.

If a capacitance standard of substantially higher value is used, the greater correction for error stemming from series inductance jeopardizes the accuracy of calibration (see paragraph 3.4.3.).

Prior to calibration the "COMP ADJ" peaking adjustment should be performed as follows:

(a) Attach the standard to the "TEST" posts, using the shortest practical lengths of coaxial cable.

(b) Set the "RANGE" selector to the lowest value on which, by adjustment of the "C ZERO" control, a reading of approximately 75% of full scale is possible.

(c) Adjust the "COMP ADJ" control for a peak reading. (Readjust the "C ZERO" control to keep deflections on-scale if necessary).

(d) Disconnect the coaxial cable from the "LO" test terminal and zero the meter using the "C ZERO" control.

Following the adjustment of the "COMP ADJ" control, proceed with the calibration check as follows:

(a) With the standard connected to the "TEST" terminals, set the "RANGE" selector to produce the greatest on-scale deflection. The meter should read the value of the standard.

(b) Shunt the standard with the resistor to simulate a Q of 3. The meter should read the value of the standard plus 0.5 pF (the capacitance of the shunting resistor). If both tests yield the appropriate values, the instrument is in calibration. Otherwise, the following calibration adjustments should be performed:

(1) With the shunting resistor removed, set the rear panel "CAL 1" adjustment so that the meter reads the value of the standard.

(2) Replace the shunting resistor and adjust "CAL 2" so that the meter reads the value of the standard plus the capacitance of the resistor.

(3) Remove the shunting resistor. If the meter indicates the standard value, the instrument is calibrated. Otherwise, repeat Steps a, b, and c until both tests yield the appropriate value.

### 3.10.4 Calibration Check of the Model 71AR with the Internal Standard Capacitor

(a) Set the instrument to the 1 pF range and adjust the "COMP ADJ" control as explained in paragraph 3.3.2.2 with no specimen at the "TEST" terminals.

(b) On completing the "COMP ADJ" peaking, switch to the 100 pF range.

(c) With the Model 71AR set to the 100 pF range and the OPERATE CAL 1/CAL 2 selector set to "CAL 1", note the meter reading.

(d) Switch to the "CAL 2" position (which reduces the Q of the standard to 3) and again check the reading.

(e) If the indicator reads 100 pF for both tests, the instrument is in calibration. Otherwise perform the following calibration adjustments:

(1) Set selector to the "CAL 1" position and adjust the "CAL 1" control at the rear panel so that the meter reads 100 pF.

(2) Set selector to "CAL 2". Adjust the "CAL 2" control at the rear panel of the instrument so that the indicator reads 100 pF.

(3) Switch back to "CAL 1". If the instrument still reads 100 pF, calibration is complete. If not, repeat Steps a, b, and c until the instrument reads 100 pF on both tests.

## 3.11 Inductance Measurements

### 3.11.1 General

With the "L/C" selector in the "L" position the Models 71A and 71AR measure two-terminal inductance. It will be noted that with the "L" position, the normal resting place of the indicator, with no specimen connected to the "INDUCTANCE" terminals, is at the extreme right, above full scale; it moves down scale only when a specimen of measureable value for that range is placed across the terminals.

## 3.12 Connections for Inductance Measurement

Inductance should be connected directly to the "INDUCTANCE" terminals. Use of connecting leads will introduce errors of measurement as shown in Fig. 3.3.

## 3.13 Inductance Zero Check

The Model 71A can be quickly checked for L zero by placing a short length of #22 copper wire tightly across the "INDUCTANCE" terminals, with the "RANGE" selector set at 1 μH. The reading should be three-quarters of a minor scale division above zero. If not, the "L ZERO" control (center adjustment on the left side of the instrument) should be adjusted for this reading. (NOTE: The controls immediately above and below the "L ZERO" control are factory adjustments and their settings should not be disturbed.)

Once adjusted as described above, the Model 71A is properly set for all inductance ranges.

### IMPORTANT NOTE

The "1000 pF ZERO" control should be properly set (see paragraph 3.4) before checking the inductance zero position. The "1000 pF ZERO" has a direct influence on inductance readings and once set, should not be disturbed during the course of measurement.

## 3.14 DC Output

### 3.14.1 General

A dc analog of the measured capacitance or inductance value is available in two modes (REC and DVM) as selected by connections at the rear panel. The output is valuable for such uses as application to a recorder, x-y plotter, digital voltmeter, voltage comparator, etc. Response time of the dc output is less than 10 milliseconds.

### 3.14.2 REC Mode

By connecting to the "REC" and common terminals, the output for all ranges varies linearly with the meter reading from 0 to a maximum of approximately 1.7 volts (into loads of 10 megohms or greater).

### 3.14.3 DVM Mode

Taking the output from the "DVM" and common terminals provides a voltage which varies from 0 to 100 millivolts or 300 millivolts for full scale deflection, depending on the numerics of the selected range. In cases where the output is used with a digital voltmeter having an input impedance of 10 megohms or greater, the resistor supplied across the terminals should be left in position. For digital voltmeters having an input impedance of 1 megohm this resistor should be removed. If the input resistance of the DVM is less than 1 megohm, the 3:1 ratio of the internal attenuator will be somewhat in error.

### 3.14.4 DVM Output Adjustment

A control for the "DVM" output is provided on the rear panel to permit setting a digital voltmeter for exact agreement with a standard capacitor. To set this adjustment, attach a standard capacitor that will produce a suitable reading (the Model 71-1A Standard Capacitor is convenient for this purpose) to the test terminals and set the range selector to the appropriate range. (The "COMP ADJ" must be properly adjusted as in paragraph 3.10.2.) With the digital voltmeter properly connected, adjust the "DVM ADJ" control so that the digital voltmeter indicates the proper value. Once adjusted for a given digital voltmeter, the Model 71A may be switched from range to range, and the digital voltmeter will follow correctly.

## 3.15 "METER ON/OFF" Switch

In cases where tests are being made at high speed in conjunction with a digital voltmeter, voltage comparator or other external monitor, the meter should be switched off by means of the rear panel "METER-OFF" switch to avoid possible interaction caused by a small counter-emf from the moving coil of the meter. Also, this avoids damage and excessive wear of the movement. Whether the meter is switched on or off has no bearing on the accuracy of the quiescent value of the dc output.

NOTE: In the Model 71AR, the "METER-OFF" switch is located on the front panel, and the rear panel meter switch is disabled.

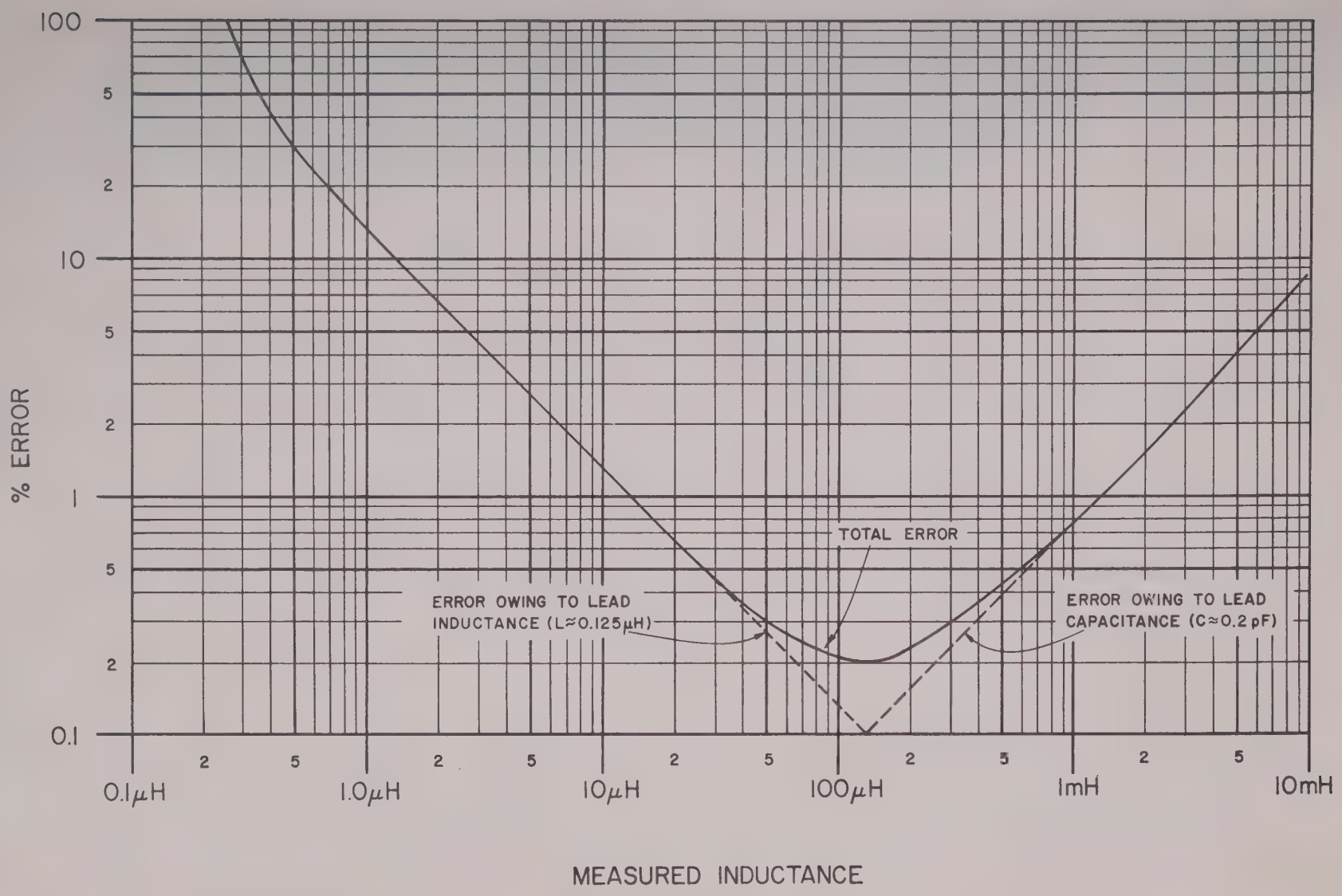

CONNECTION ERROR RESULTING FROM 3 INCH LEADS
OF NO. 20 WIRE SPACED 3/4 INCHES APART
100
5
2
10
5
2
1
5
2
0.1
% ERROR
TOTAL ERROR
ERROR OWING TO LEAD
INDUCTANCE (L≈0.125μH)
ERROR OWING TO LEAD
CAPACITANCE (C≈0.2 pF)
2
5
2
5
2
5
2
5
2
5
0.1μH
1.0μH
10μH
100μH
1mH
10mH
MEASURED INDUCTANCE

Figure 3-3

## SECTION IV

### List of Replaceable Parts - Models 71A-71AR

| Reference | Description | | | | | BEC Part No. |
|---|---|---|---|---|---|---|
| C101 | Capacitor | | 0.1 | uF | 200V | 230116 |
| C102 | " | Var. | 1.8-8.7 | pF | | 275138 |
| C103 | " | | 91 | pF | 500V | 200035 |
| C103* | " | | 120 | pF | 500V | 200002 |
| C104 | " | Var. | 3.8-50 | pF | | 275139 |
| C105 | " | Var. | 0.7-3 | pF | | 279109 |
| C106 | " | | 0.033 | µF | 200V | 234045 |
| C107 | " | Var. | 140 | pF | | 275104 |
| C108 | " | | 0.02 | µF | 500V | 224118 |
| C109 | " | | 0.02 | µF | 500V | 224118 |
| C110* | " | | 97 | pF | 500V | 200040 |
| C111* | " | Var. | 0.7-3.0 | pF | | 279109 |
| C112* | " | Var. | 0.7-3.0 | pF | | 279109 |
| C201 | " | | 0.01 | µF | 200V | 234027 |
| C202 | " | | 0.02 | µF | 500V | 224118 |
| C203 | " | | 0.1 | µF | 25V | 224124 |
| C204 | " | | 0.02 | µF | 500V | 224118 |
| C205 | " | | 150 | pF | 500V | 200032 |
| C206 | " | | 0.02 | µF | 500V | 224118 |
| C207 | " | | 0.01 | µF | 200V | 234027 |
| C208 | " | | 0.1 | µF | 25V | 224124 |
| C209 | " | | 0.02 | µF | 500V | 224118 |
| C210 | " | | 150 | pF | 500V | 200032 |
| C211 | " | | 0.02 | µF | 500V | 224118 |
| C212 | " | | 0.01 | µF | 200V | 234027 |
| C213 | " | | 91 | pF | 500V | 200035 |
| C214 | " | Var. | 7-45 | pF | 500V | 275114 |
| C215 | " | | 0.02 | µF | 500V | 224118 |
| C216 | " | | 150 | pF | 500V | 200032 |
| C217 | " | | 0.02 | µF | 500V | 224118 |
| C218 | " | | 470 | pF | 500V | 200028 |
| C301 | " | | 0.02 | µF | 500V | 224118 |
| C302 | " | | 0.02 | µF | 500V | 224118 |
| C303 | " | | 0.02 | µF | 500V | 224118 |
| C304 | " | | 0.1 | µF | 200V | 230116 |
| C305 | " | | 430 | pF | 500V | 200037 |
| C306 | " | | 430 | pF | 500V | 200037 |
| C307 | " | | 0.022 | µF | 200V | 230101 |
| C308 | " | | 0.022 | µF | 200V | 230101 |
| C401 | " | | 56 | pF | 500V | 200030 |
| C402 | " | | 250 | pF | 500V | 200036 |



*Model 71AR only

| Reference | | Description | | | | BEC Part No. |
|---|---|---|---|---|---|---|
| C403 | Capacitor | 0.02 | µF | | 500V | 224118 |
| C404 | " | 0.02 | µF | | 500V | 224118 |
| C405 | " | 0.02 | µF | | 500V | 224118 |
| C406 | " | 0.02 | µF | | 500V | 224118 |
| C407 | " | 0.001 | µF | | 500V | 224114 |
| C408 | " | 10 | µF | | 6V | 283130 |
| C409 | " | 20 | µF | | 6V | 283153 |
| C410 | " | 0.01 | µF | | 200V | 234027 |
| C411 | " | 1.0 | µF | | 100V | 283175 |
| C412 | " | 25 | µF | | 6V | 283177 |
| C501 | " | 0.1 | µF | | 200V | 230116 |
| C502 | " | 500 | µF | | 3V | 283180 |
| C503 | " | 0.02 | µF | | 500V | 224118 |
| C504 | " | 0.02 | µF | | 500V | 224118 |
| C505 | " | 0.02 | µF | | 500V | 224118 |
| C601 | " | 0.01 | µF | | 400V | 234021 |
| C602 | " | 0.01 | µF | | 400V | 234021 |
| C603 | " | 50 | µF | | 12V | 283176 |
| C604 | " | 20/20 | µF | | 450V | 283100 |
| R101 | Resistor | 47K | Ω | 5% | 1/2W | 301127 |
| R102 | " | 169 | Ω | 1% | 1/4W | 315068 |
| R103 | " | 511 | Ω | 1% | 1/4W | 315080 |
| R104 | " | 1.65K | Ω | 1% | 1/4W | 315092 |
| R105 | " | 4.99K | Ω | 1% | 1/4W | 315103 |
| R106 | " | 16.9K | Ω | 1% | 1/4W | 315117 |
| R107 | " | 53.6K | Ω | 1% | 1/4W | 315133 |
| R108 | " | 178K | Ω | 1% | 1/4W | 315141 |
| R109 | " | 6.65K | Ω | 1% | 1/4W | 315107 |
| R110 | " | 2.1K | Ω | 1% | 1/4W | 315095 |
| R111 | " | 604 | Ω | 1% | 1/4W | 315082 |
| R112 | " | 205 | Ω | 1% | 1/4W | 315070 |
| R113 | " | 60.4 | Ω | 1% | 1/4W | 315058 |
| R114 | " | 19.6 | Ω | 1% | 1/4W | 315045 |
| R115 | " | 10 | Ω | 1% | 1/4W | 315039 |
| R116 | " | 13 | Ω | 1% | 1/4W | 315042 |
| R117 | " | 220K | Ω | 5% | 1/2W | 301143 |
| R119* | " | 4.7K | Ω | 5% | 1/2W | 301103 |
| R201 | " | 1K | Ω | 5% | 1/2W | 301087 |
| R202 | " | 510K | Ω | 5% | 1/2W | 301152 |
| R203 | " | 820 | Ω | 5% | 1/2W | 301085 |
| R204 | " | 10 | Ω | 1% | 1/4W | 315039 |
| R205 | " | 330K | Ω | 5% | 1/2W | 301147 |
| R206 | " | 470 | Ω | 5% | 1/2W | 301079 |



*Model 71AR only

| Reference | Description | | | | BEC Part No. |
|---|---|---|---|---|---|
| R207 | Resistor | Factory Selected | | | |
| R208 | " | 1.21K Ω | 1% | 1/4W | 315089 |
| R209 | " | 1K Ω | 5% | 1/2W | 301087 |
| R210 | " | 510K Ω | 5% | 1/2W | 301152 |
| R211 | " | 820 Ω | 5% | 1/2W | 301085 |
| R212 | " | 330K Ω | 5% | 1/2W | 301147 |
| R213 | " | 470 Ω | 5% | 1/2W | 301079 |
| R214 | " | 1K Ω | 5% | 1/2W | 301087 |
| R215 | " | 510K Ω | 5% | 1/2W | 301152 |
| R216 | " | 150 Ω | 1% | 1/4W | 315067 |
| R217 | " | 390 Ω | 5% | 1/2W | 301077 |
| R218 | " | 33K Ω | 5% | 1/2W | 301123 |
| R219 | " | 27K Ω | 5% | 1/2W | 301121 |
| R220 | " | 470 Ω | 5% | 1/2W | 301079 |
| R301 | " | 2K Ω | 5% | 1/2W | 301094 |
| R302 | " | 470 Ω | 5% | 1/2W | 301079 |
| R303 | " | 6.8K Ω | 5% | 1/2W | 315012 |
| R304 | Potentiometer | 1K Ω | 20% | | 311100 |
| R305 | Resistor | 6.8K Ω | 5% | 1/2W | 315012 |
| R401 | " | 68K Ω | 5% | 1/2W | 301131 |
| R402 | " | 180K Ω | 5% | 1/2W | 301141 |
| R403 | " | 110 Ω | 5% | 1/2W | 301064 |
| R404 | " | 470 Ω | 5% | 1/2W | 301079 |
| R405 | " | 33K Ω | 5% | 1W | 302137 |
| R406 | " | 33K Ω | 5% | 1W | 302137 |
| R407 | Potentiometer | 10K Ω | 20% | | 311102 |
| R408 | Resistor | 43K Ω | 5% | 1/2W | 315005 |
| R409 | " | 160K Ω | 5% | 1/2W | 315440 |
| R410 | " | 160K Ω | 5% | 1/2W | 315440 |
| R411 | " | 6.8K Ω | 5% | 1/2W | 315012 |
| R412 | " | 1.5M Ω | 5% | 1/2W | 301163 |
| R413 | " | 20K Ω | 5% | 1/2W | 301118 |
| R414 | " | 100 Ω | 1% | 1/2W | 306120 |
| R415 | Potentiometer | 3K Ω | 20% | | 311112 |
| R416 | Resistor | 20K Ω | 5% | 1/2W | 301118 |
| R417 | " | 100 Ω | 1% | 1/2W | 306120 |
| R418 | " | 1 Meg Ω | 5% | 1/2W | 301159 |
| R419 | " | 33K Ω | 5% | 1/2W | 301123 |
| R420 | " | 130K Ω | 5% | 1/2W | 301138 |
| R421 | " | 2.7K Ω | 5% | 1/2W | 301097 |
| R422 | " | 2.2M Ω | 5% | 1/2W | 301167 |
| R423 | " | 51K Ω | 5% | 1/2W | 301128 |
| R424 | " | 20K Ω | 5% | 1/2W | 301118 |
| R425 | " | 100 Ω | 1% | 1/2W | 306120 |

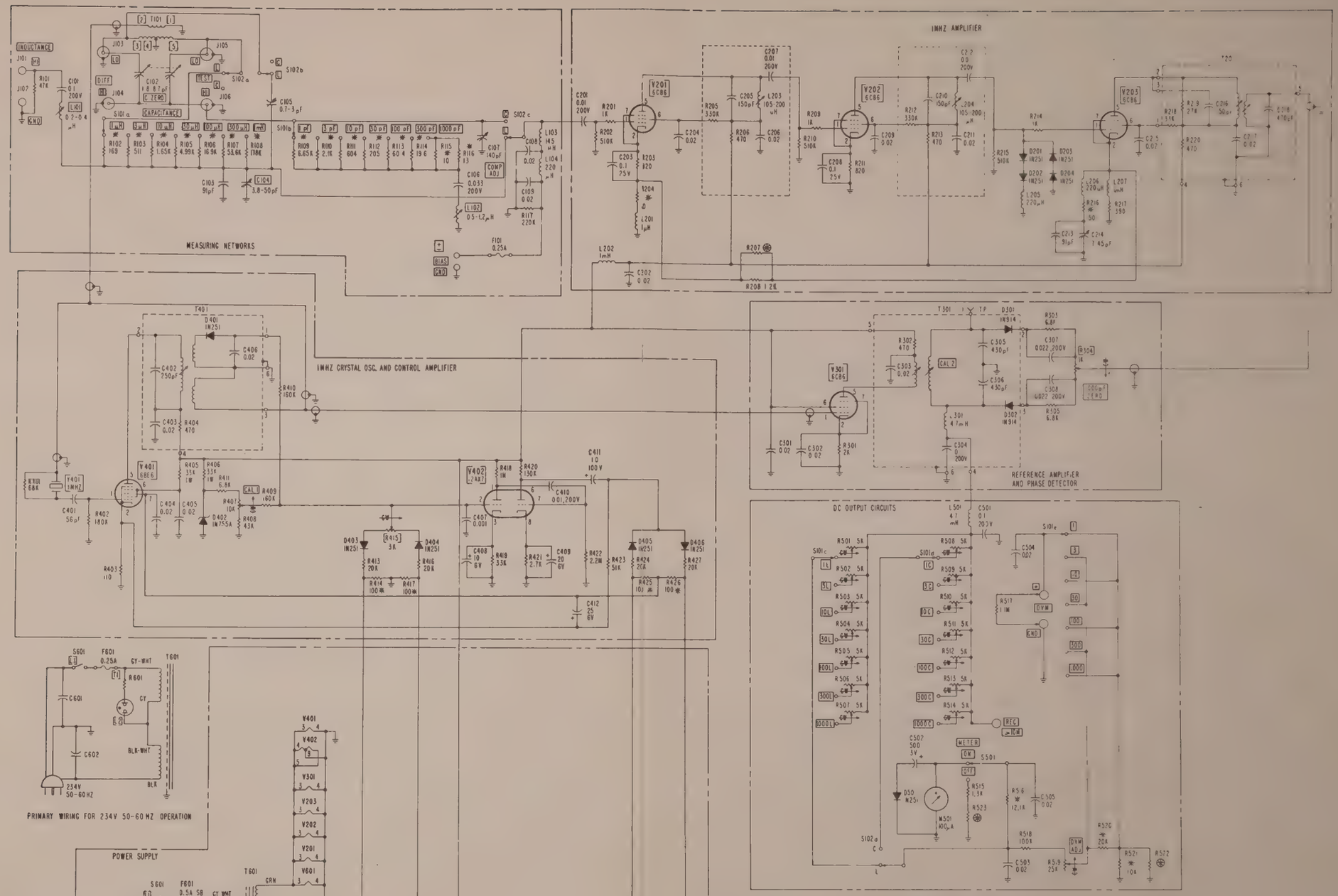
| Reference | Description | | | | BEC Part No. |
|---|---|---|---|---|---|
| J101 | Binding Posts | | | | 740138 |
| J102 | Binding Posts | | | | 740138 |
| J103 | Connectors, Coaxial | | | | 479123 |
| J104 | " | | | | 479123 |
| J105 | " | | | | 479123 |
| J106 | " | | | | 479123 |
| L101 | Inductor | 0.2 to 0.4 | µH | | 400123 |
| L102 | " | 0.5 to 1.2 | µH | | 400122 |
| L103 | " | 145 | µH | | 400124 |
| L104 | " | 220 | µH | | 400118 |
| L201 | " | 1 | µH | 20% | 400120 |
| L202 | " | 1 | mH | 5% | 400095 |
| L203 | " | 105 to 200 | µH | | 400117 |
| L204 | " | 105 to 200 | µH | | 400117 |
| L205 | " | 220 | µH | 5% | 400118 |
| L206 | " | 220 | µH | 5% | 400118 |
| L207 | " | 1 | mH | 5% | 400095 |
| L301 | " | 4.7 | mH | 5% | 400102 |
| L501 | " | 4.7 | mH | 5% | 400102 |
| L601 | Choke | 7H; 50 mA | | | 440001 |
| M501 | Meter | 0-100 µA | | | 554168 |
| S101 | Switch | | | | 466179 |
| S102 | Switch | | | | 466176 |
| S103* | Switch | | | | 466183 |
| S501 | Switch | | | | 465112 |
| S601 | Switch | | | | 465113 |
| T101 | Transformer, Input | | | | 071012 |
| T201 | Transformer, Output | | | | 071007 |
| T301 | Transformer, Detector | | | | 071009 |
| T401 | Transformer, Oscillator | | | | 071008 |
| T601 | Transformer, Power | | | | 446025 |



*Model 71AR only

| Reference | Description | BEC Part No. |
|---|---|---|
| R426 | Resistor 100 Ω 1% 1/2W | 306120 |
| R427 | " 20K Ω 5% 1/2W | 301118 |
| R501 Thru R514 Inc. | Potentiometers 5K Ω 20% | 311101 |
| R515 | Resistor 1.3K Ω 5% 1/2W | 301090 |
| R516 | " 12.1K Ω 1% 1/2W | 315413 |
| R517 | " 1.1M Ω 5% 1/2W | 301160 |
| R518 | " 100K Ω 5% 1/2W | 315023 |
| R519 | Potentiometer 25K Ω 20% | 311115 |
| R520 | Resistor 20K Ω 1% 1/2W | 315418 |
| R521 | " 10K Ω 1% 1/2W | 315411 |
| R522 | " Factory Selected | |
| R523 | " Factory Selected | |
| R601 | " P/o Switch-Indicator Assembly | |
| R602 | Potentiometer 250K Ω 20% | 311103 |
| R603 | Resistor 100 Ω 5% 1/2W | 301063 |
| R604 | " 1 Meg Ω 5% 1/2W | 301159 |
| R605 | " 4K Ω 5% 10W | 312119 |
| D201 | Diode 1N251 | 530043 |
| D202 | " 1N251 | 530043 |
| D301 | " 1N914 | 530058 |
| D302 | " 1N914 | 530058 |
| D401 | " 1N251 | 530043 |
| D402 | " 1N755A | 530066 |
| D403 | " 1N251 | 530043 |
| D404 | " 1N251 | 530043 |
| D405 | " 1N251 | 530043 |
| D406 | " 1N251 | 530043 |
| D501 | " 1N251 | 530043 |
| D601 | " 1N251 | 530043 |
| F101 | Fuse 0.25A AGC 1/4 | 545506 |
| F601 | Fuse(117V Models) 0.5A MDL 1/2 250V | 545504 |
| F601 | " (230V Models) 0.25A MDL 1/4 250V | 545511 |

| Reference | | Description | BEC Part No. |
|---|---|---|---|
| V201 | Tube | 6CB6 | 526 6CB6 |
| V202 | Tube | 6CB6 | 526 6CB6 |
| V203 | Tube | 6CB6 | 526 6CB6 |
| V301 | Tube | 6CB6 | 526 6CB6 |
| V401 | Tube | 6BE6 | 526 6BE6 |
| V402 | Tube | 12AX7 | 526 12AX7 |
| V601 | Tube | 6X4 | 526 6X4 |
| V602 | Tube | OA2 | 526 OA2 |
| Y401 | Crystal | 1MHz | 547015 |




NOTES:
VOLTAGE RATING OF CAPACITORS IS 500 VOLTS UNLESS OTHERWISE SPECIFIED
⊛ FACTORY SELECTED VALUE
✱ PRECISION RESISTORS, 1/4 W
CAPACITANCE IN μF UNLESS OTHERWISE SPECIFIED
RESISTANCE VALUES IN OHMS AND 1/2 WATT UNLESS OTHERWISE SPECIFIED
▭ EXTERNAL MARKINGS [ ] INTERNAL MARKINGS

LAST NUMBERS USED:

| | | | |
|---|---|---|---|
| R117 | R427 | C109 | C412 |
| R220 | R523 | C218 | C505 |
| R305 | R605 | C308 | C604 |

Model 71A Schematic
Dwg. No. 830338K
(For Serial Nos. 847 & Up)

# Warranty

Boonton Electronics Corporation warrants its products to the original Purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to vacuum tubes that have given normal service, to sealed assemblies which have been opened, or to any item which has been repaired or altered without our authorization.

We will repair or, at our option, replace at no charge any of our products which are found to be defective under the terms of this warranty.

# SHIPPING INSTRUCTIONS

If it becomes necessary to ship the instrument, the following steps should be followed:

a. Wrap the instrument with heavy wrapping paper and seal the seams with gummed tape. Place in fibreboard carton large enough to permit three inches of soft packing material between instrument and sides of box.

b. Alternatively Boonton Electronics will provide an appropriate shipping container and packing materials at nominal cost. These may be obtained by writing to the Sales Department, Boonton Electronics Corporation, Route 287 at Smith Rd., Parsippany, N. J. 07054.

www.manualsplus.com
1027352